MAIN LECTURE

Re-visiting the nutrition of dairy sheep grazing Mediterranean pastures

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ABSTRACT: In the light of recent findings in sheep nutrition and behaviour, the diets of grazing dairy sheep should be based on forages encompassing a variety of complementary nutritional values and containing moderate levels of complementary plant secondary metabolites, until recently regarded as "anti-nutritional". In lactating sheep, pastures of tannin-containing legumes like sulla (*Hedysarum coronarium*) and chicory (*Cichorium intybus*) can be integrated with annual grasses for establishing sustainable artificial pastures under rainfed conditions. Diets based on these forages, while ensuring high milking performance, can mitigate the unbalance of CP to energy ratio of grazing sheep. By grazing sulla and annual or Italian ryegrass (50:50 by area) as spatially conterminal monocultures or in timely sequence (complementary grazing) sheep eat more and perform better than by grazing the ryegrass pasture only. Concentrate supplementation of lactating sheep should be preferably based on fibrous sources (soyhulls or beet pulps), particularly from mid-lactation onwards and when supplementation levels are high. Milk urea concentration is confirmedly a useful monitoring tool to balance protein nutrition and curb the waste of N at animal and system level.

Key words: Grazing, Sheep, Nutrition, Behaviour.

INTRODUCTION – Although great efforts have been made in the last decade to clarify the functioning of the grazing system, many aspects and research areas are still overlooked. This is particularly the case for the interaction between dairy sheep and Mediterranean-type pastures on which they graze. This review is aimed at updating the above subject thanks to: i) recent research outcome specifically focussed on lactating sheep fed at pasture; ii) evidence based on more fundamental research on sheep behaviour and nutrition. We will basically focus on the feeding behaviour, intake and performance responses of lactating dairy sheep fed on forage crops or improved semi-natural pastures (semi-extensive farming systems). Aspects such as agronomic performance and the release of N to the environment will also be briefly discussed.
Before embarking on the description of the above mentioned topics, it must be stressed that a new concept of nutrition of grazing ruminants has clearly emerged in the last decade, e.g., pasture specialists depart from the monoculture approach ('if sheep graze this, their average animal daily requirements should be met') that was often challenged by unexpected animal behaviours at pasture. A more animal-friendly approach can be envisaged, encompassing a 'dialogue' between man and animal, which keeps in mind the grazing system as a whole in a multi-disciplinary perspective. The animal component of this 'dialogue' is based on animal behaviour (i.e. the 'body language'). Therefore behavioural variables such as 'animal preference' should complement the classical nutritional variables (i.e. requirements & feed nutritive value). The convenience to take preference on board while managing the nutrition of grazing animals stands on the widely accepted concept that preference is well related to long-term animal adaptation to its environment which is a pre-requisite for optimal life-long performance (Prache and Peyraud, 2001). One of the corner pillars of feeding behavioural science is that preference for a food is everchanging because of spatially and timely modified environments. Also, feeding behaviour has a strong individual component. Therefore, a prominent new principle is that: herbivores' diet has to be diverse (Provenza *et al.*, 2007). The new approach implies a new target: production of quality foods modulated by agronomic, economic, ethical (e.g. animal well-being) and environmental considerations. This is well in line with the development of regional dairy sheep production systems, which represent the core of Mediterranean dairy sheep industry (Landau and Molle, 2004, Morand-Fehr *et al.*, 2007).

CHOICE OF PASTURE FORAGES: IS THERE AN HERBAGE 'IDEOTYPE' FOR DAIRY SHEEP? – Mediterranean grazed forages consist primarily of annual species, which undergo abrupt changes in their nutritive value during the course of the growing cycle. Sheep will usually graze from the top leafy layer downwards therefore the quality of the ingested forage is higher than that on offer.

Table 1. Dry matter (g/kg), chemical composition (g/kg DM) and nutritive value of some Mediterranean forage as selected by lactating sheep (hand-plucked samples). Means and (s.d.).

Forage	N	DM	CP	NDF	NFC[1]	Tannic phenols	NEL[2] (Mcal/kg DM)	CP/NEL (g/Mcal)
Annual ryegrass[3]	72	194 (32)	219 (41)	414 (52)	227 (88)	3 (1)	1.79 (0.1)	123 (25)
Sulla[3]	24	164 (18)	232 (40)	310 (62)	334 (102)	21 (6)	1.70 (0.2)	140 (35)
Burr medic[3]	24	191 (28)	281 (12)	296 (52)	301 (51)	2 (1)	1.78 (0.1)	159 (10)
Subclover[3]	24	196 (19)	216 (20)	317 (53)	315 (63)	10 (3)	1.62 (0.1)	131 (17)
Sulla[4]	3	157 (24)	234 (27)	377 (25)	254 (57)	26 (1)	1.47 (0.1)	160 (25)
Burr medic[4]	3	181 (39)	241 (28)	359 (61)	273 (35)	6 (1)	1.62 (0.1)	148 (6)
Chicory[4]	3	120 (29)	145 (9)	350 (7)	337 (16)	10 (4)	1.62 (0.0)	90 (5)
Safflower[4]	3	150 (15)	172 (39)	379 (83)	302 (42)	24 (10)	1.64 (0.3)	105 (6)

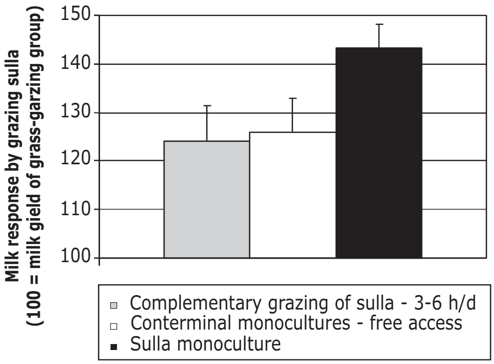
[1]NFC = 100-Ash-CP-EE-NDF (all as % DM); [2]Calculated at 4 times the maintenance level of feeding (Cannas et al., 2004); [3]Forages at growth phase (January to April); [4]Forages at early reproductive phase (May), Landau et al., 2005.

As shown in Table 1, the selected components of both grass and legume forages have a high nutritive value during growth period. However, the CP to energy ratio is above the required levels for milk production (approximately 110-120 g CP/Mcal NEL for milk yield ranging between 1000 and 2000 g/d). In grasses this ratio starts dropping from the beginning of heading, when the contribution of most nutritional components (leaves) in total biomass decreases, with concomitant depreciation of nutritive value. Indeed sheep that are grazing mature grass pastures (standing hay) during early summer can experience CP deficit conditions with impairment of intake and reproductive performance. This is not necessarily the case when legumes at reproductive phase are the main feed source (Table 1). It is then evident that sheep often experience high CP to energy ratios in their diet which bring about: i) metabolic costs for detoxifying ammonia to urea in the liver; ii) increased N excretion, mostly as urine; iii) low nitrogen utilisation efficiency with a negative impact on the release of N to the environment; and iv) -possibly- health problems. Although the intensity of some of these shortcomings (e.g. the cost of NH_3 detoxification) still warrants a thorough assessment in sheep traditionally fed on pasture, (cfr. Iason and Villalba, 2006) data accumulated so far suggest that these problems are to be tackled. At large, no unique solution can be put forward to cope with this unbalance. For sure one can be easily ruled out which is: no monoculture of any Mediterranean pasture species is balanced for CP/energy for more than a short bout of the grazing season. Nevertheless there are ways to mitigate the excess of CP - mainly degradable protein - with respect to energy:

- By increasing the content of non-fiber carbohydrates (NFC) and in particular water soluble carbohydrates (WSC) by genetic or environmental means;
- By lowering the degradability of N in a way to reduce the ammonia loss at rumen level. This can be done for instance using forages inclusive of condensed tannins;
- By using supplements to counterbalance the CP excess (e.g. starchy concentrates, see below).

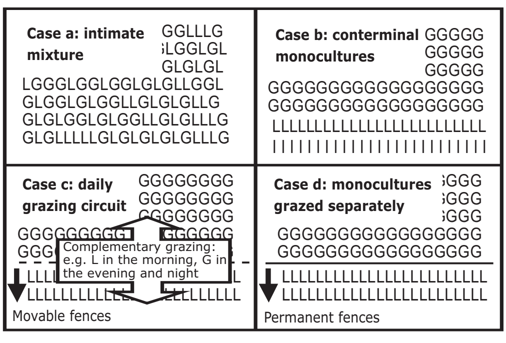
As far as the first point is concerned, the grazed plant usually contains a 5-20 % (grass) or 3-12% (legumes) of WSC (mostly sucrose and fructans) depending on forage species and variety, phenological stage (higher at the beginning of flowering or heading), weather pattern (higher under sunny conditions), the time of day (higher in the afternoon), soil nutrition (lower with abundant N fertilisation) and grazing management (higher under rotational grazing than continuous stocking, Jarrige *et al.*, 1995). Recently new cultivars of perennial ryegrass (*Lolium perenne*) have been selected whose WSC contents overpass by 20-40% (DM basis) the standard cultivar levels across all growing season (Lee et al., 2001). These authors found a higher average daily gain in lambs grazing an elevated WSC variety as compared to a control as well as an increased carrying capacity which resulted in 23% higher gain per hectare (P<0.06). In a parallel in vitro gas production test, Lee et al. (2002) found an increase of fermentation rate and glucogenic/lipogenic ratio as well as a reduction of ammonia concentration by the WSC-enriched ryegrass. These encouraging results in sheep were confirmed in dairy cows with positive consequences on in vivo DM digestibility, intake of digestible DM, milk yield and N utilisation efficiency in late-lactating cows fed fresh forages of perennial ryegrass (cv. Aberdove) as compared with a control variety with lower WSC (Miller *et al.*, 2001). In contrast, Taweel *et al.* (2005) and Tas (2005), working with dairy cattle in the Netherlands, were unable to detect the above effects. However their results can be partly explained by the moderate difference in WSC between the cultivars and from a higher crown rust (*Puccinia coronata* f. sp. *lolii*) infestation in the WSC enriched variety. In general, while increasing the WSC in grazed herbage can be advised for many implications, including the enhancement of preference in sheep (Dove *et al.*, 1999) research results regarding the responses to WSC genetically enriched forages are not conclusive yet. The technique of spray-topping low doses of glyphosate for enhancing the WSC in annual grass-based pastures (Siever-Kelly *et al.*, 1999) is relatively unattractive for the perception it gives of being hazardous for the environment.

Figure 1. Milk response to grazing sulla as monoculture or conterminal association with ryegrass spp. (50:50 by area) as free choice or complementary grazing (sulla in the morning and the rest on ryegrass). Molle et al., 1998, 2000, 2003; Di Miceli et al., 2005, Bonanno et al., 2007. Means and SEM.



In contrast, the inclusion in sheep diet of pasture legumes containing moderate levels of condensed tannins (CT) such as the short-lived sulla *(Hedysarum coronarium)* and sainfoin *(Onobrychis sativa)* and the long-lived perennial birdsfoot trefoil *(Lotus corniculatus)* has gained an overt consensus among scientists (Mueller-Harvey, 2006). This is due to evidence such as: higher intake (in some circumstances), lower ammonia concentration in the rumen, higher uptake of amino acids at gut level, overall lower N excretion, lower emission of N and CH_4 to atmosphere, improved resilience to gastro-intestinal parasites, and last but not least, better animal performance. Among these forage species, sulla, beside the moderate content of CT, displays a relatively high NFC level (Table 1). A summary on the responses by dairy sheep grazing sulla as monoculture or in association with grasses (annual ryegrass, *Lolium rigidum* Gaudin or Italian ryegrass, *Lolium multiflorum*) is shown in figure 1. These results stem from studies on Sarda and Comisana ewes grazing at moderate to high stocking densities (20-80 ewes ha^{-1}) without supplementation. They highlight the potential of sulla as monoculture in improving milk performance in dairy sheep during spring (mid-late lactation phase) owing to the higher intake of this forage as compared with ryegrass spp. (on average +20%). Moreover the figure indicates that sulla can be associated with annual grasses both spatially, as conterminal (adjacent) monoculture or temporally as grazing sequence, where sheep ingest more herbage (on average +10%) and produce more milk than with the grass monoculture. Burke *et al.* (2002) found better daily gain and feeding efficiency in lambs fed fresh sulla or its mixture (50:50 on DM basis) with either white clover or lucerne as compared with freshly cut grass-based pastures. They also found that the mixture (50:50) of sulla with the grass pasture gave intermediate results as compared with the corresponding monoculture-based diets. The preference for

Figure 2. Examples of spatial distribution of two complementary species represented by different letters.



sulla has been recently assessed by Rutter *et al.* (2004) using conterminal monocultures of annual ryegrass and sulla grazed by Sarda lactating sheep. The average preference, expressed as percentage of total grazing time, was 74%, which is close to 70%, the value usually found in sheep grazing white clover-perennial ryegrass conterminal monocultures (Rutter, 2006). Another finding was that preference for sulla, almost complete in the first two grazing hours in the morning, decreased rapidly along with the time on the pasture. The accumulation of CT in sheep rumen along with the grazing process has been evoked to explain this behaviour. Villalba and Provenza (2002) in lambs submitted to preference trials indoors found that when tannin ingestion increased, the satiation on the tannin-containing food likely encouraged them to explore alternative sites to get non-tannic feedstuffs. In a more recent study (Giovanetti *et al.*, 2006) sheep grazing a sulla monoculture at flowering (which is usually the CT peak period) but drenched with 100 g/d of polyethylene glycol (MW 4000) (i.e. not exposed to CT effect), exhibited longer grazing time ($P<0.07$), than counterparts drenched with water (exposed to CT effect).

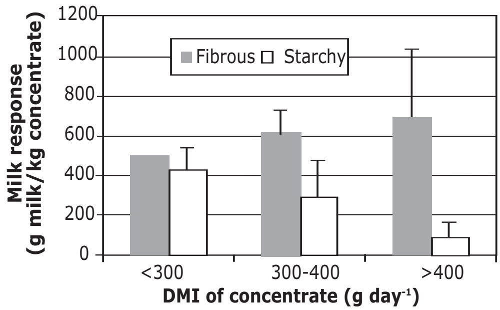
Although sulla is an outstanding legume for the reasons already stated it has the shortcoming of not adapting well to acidic and sandy soils. Other forage legumes can be envisaged for inclusion in pastures for dairy sheep in association with grasses such as the ryegrass spp.. However species such as the berseem clover (*Trifolium alexandrinum*), Persian clover (*Trifolium resupinatum*) or the self-regenerating burr medic (*Medicago polymorpha*) while providing good herbage production and production responses (see review by Rochon *et al.*, 2004) overall show some disadvantages from the nutritional viewpoint as compared with the above quoted tannin-containing legumes. For burr medic an extreme CP to energy ratio (Table 1) can bring about an important waste of N when grazed either as monoculture (Molle *et al.*, 2002) or grass-legume binary mixture (Molle *et al.*, 2007). Alternative forage species belonging to daisy (*Compositae*) family can be usefully included in pastures for dairy sheep. Chicory (*Cichorium intybus*) is an interesting short-lived perennial forage with a tap rooting system, which allows it to extend its growth cycle up to the end of spring, even without irrigation. Nutritionally speaking, this forage is a good source of NFC such as inulin, it is also relatively low in fiber and has a lower CP content than legumes in late-spring, when it could be the only green forage available under rainfed conditions (Table 1). Moreover chicory contains plant secondary metabolites such as phenolic compounds and sesquiterpene lactones which are thought to elicit a positive effect against gastro-intestinal parasite infestation (e.g. Athanasiadou *et al.*, 2006). Chicory monocultures rotationally grazed by Sardinian dairy sheep gave milk performance as good as sulla monocultures across three grazing seasons (Sitzia *et al.*, 2006). In another study, late-lactating sheep were grazed three pasture types based respectively on chicory, another daisy, the annual safflower (*Carthamus tinctorius*) and burr medic in May-June (Landau *et al.*, 2005). Chicory-grazing sheep tended to produce more milk ($P>0.05$) and showed higher body gain than the other groups. They also displayed significantly lower milk urea concentration (MUC) indicating a better N utilisation. Safflower gave slightly lower performance responses but a lower milk protein content. Safflower, as well as another daisy plant, the garland (*Chrysanthemum coronarium*) contains also terpenes which can partially impair rumen function. Terpenes were evoked to explain the very limited intake and poor performance of sheep fed fresh garland at flowering as sole feed (Addis *et al.*, 2005). In contrast, when grazed by late-lactating sheep as a mixture with annual ryegrass and burr medic it represented around 30% (DM basis) of the diet and milk performance was as good as the binary mixture without garland (Cabiddu *et al.*, 2006a). Results of recent preference trials have clarified that acclimatized sheep can counteract the effect of ingesting a toxic metabolite by that of another toxin, provided the detoxifying mechanism is not the same for both toxins. Examples of complementary toxic plant secondary metabolites are nitrates and oxalates from one hand, tannins, terpenes and oxalates to the other as reviewed by Provenza *et al.* (2007). The bottom line of this section is that from the nutritional and behavioural standpoints, the choice of forages for sustainable sheep grazing systems should be focussed on combinations of species having complementary nutritional values and containing a variety secondary compounds, offering the sheep some degree of freedom to adjust their diets. A pre-requisite of this choice is the adequacy of these forages for their agronomic performance, namely biomass production and its distribution within and across grazing seasons (persistency). Attention should also be directed to their effect on food quality, inclusive of nutracines and sensory properties of dairy and meat products (Cabiddu *et al.*, 2005 and Pulina *et al.*, 2006 for sheep dairy products, Vasta and Priolo, 2006, with reference to lamb meat).

CHOICE OF ESTABLISHMENT AND GRAZING MANAGEMENT OF GRAZED FORAGES – While considering the management of a grazed forage one can think to either forage crops, which are to be established, or natural/semi natural permanent pastures. We will primarily approach the former scenario. The spatial distribution of different forages in a cultivated pasture (e.g. a grass (G) and a legume (L) in Figure 2) can range from intimate mixture (Case a) to monocultures in different paddocks (Cases d). Intermediate cases are patchy distribution of the two species within the same paddock, which can be exemplified by conterminal monocultures to which animals have free access (Case b). Another possibility is to have temporary fencing (e.g. electric movable fences) between conterminal monocultures with grazers having access to them in succession (Case c). Time on pasture can be then split in two or more meal 'blocks'. This is the simplest possible grazing circuit (the French 'parcours', Dumont *et al.*, 2001). Each option has its own costs and benefits. From the behaviour standpoint, scientific evidence has been recently accumulated suggesting that, probably due to higher cost of selection, intimate mixtures (Case a) tends to reduce intake and performance of sheep as compared with a patchy distribution of the different forages as found in meat sheep grazing white clover-perennial ryegrass or subclover-perennial ryegrass monocultures (reviewed by Chapman *et al.*, 2007). Intimate mixtures have complex dynamics, which are often conducive to dominance of one species over the others. Adequate fertilisation, weed control and alternative uses such as hay making at a specific phenological phase, are all more difficult under these conditions. Free choice of conterminal strips of different species (Case b) let sheep express their preference as long as the availability of the preferred forage decreases down to a 'switch point' below which the previously less preferred forage begins to contribute more to sheep diet, often at the same proportion of the preferred forage (Rook *et al.*, 2002, Prache *et al*., 2006). This preferential pasture depletion, although mitigated along the defoliation process, can be conducive to under-grazing of the less preferred forage as found by Molle *et al.* (2000) with sulla-annual ryegrass and by Prache *et al.* (2006) with perennial ryegrass-fescue paired monocultures. In contrast, the grazing circuit (which is the basis of traditional shepherding) lets sheep express their preference to an extent, which does not result in marked under-grazing of the less preferred forage if the time access on each forage is adequately tuned. In this case the best option is to offer the more preferred forage (e.g. the legume) in the morning and the less preferred forage (e.g. the grass) in the afternoon (Rutter, 2006). It is likely that the intake of the grass is boosted in the main evening meal by the post-ingestive effect of the legume as well as the need to increase the intake of dietary fibre in order to ruminate it at night and post-pone the uptake of nutrients when grazing is impaired by darkness and predator hazard. The Case d, alternating monocultures established in permanent paddocks from day to day or period to period, although possible, can be regarded as the less sensible in the light of obvious nutritional considerations. With reference to the environmental facet, the proposed spatial distribution of forages can be regarded in general as sustainable with reference to the N leaching hazard. By rotating the monocultures (cases b-d), N accumulated underneath legume swards can be efficiently up-taken by the following grass crop. In the case (a) however a more immediate and –possibly- efficient transfer of N from the legume to the grass component is expected.

Whatever the spatial distribution of forages, the grazing method can range from a continuous to an intermittent approach. Rationed grazing (limiting the time access on the pasture) can also be envisaged, for instance to modulate the trampling impact on vegetation. However it must be recognized that rationed grazing may limit the herbage intake by sheep, particularly if herbage allowance is low (Iason *et al.*, 1999). Basic criteria for a sensible choice of grazing methods were detailed and discussed elsewhere (Molle *et al.*, 2004). Stocking density has an overwhelming influence on grazing method response. It is in fact the grazing intensity that modulates the allowance and hence the intake of grazing sheep. This is relevant for forage crops but even more for natural grassland or rangeland, which often cover the higher proportion of dairy sheep farm land. Low production grazing land (rough grazing) was traditionally regarded as unsuitable for being managed using intensive grazing methods. The classical approach (lenient grazing under continuous stocking) however tends to favour the dispersion of less preferred, so called 'unpalatable' species. They often contain plant secondary metabolites, which have some anti-nutritional components. Although information referred to dairy sheep is lacking on this subject, results of fundamental research and some grazing experiments (Provenza *et al.*, 2007), indicate that for curbing this process it is necessary to increase the instant stocking density in order to force sheep familiarizing with the less palatable forages and 'train' their detoxification systems. The earlier is the exposure in sheep life the longer the benefit last during their productive career. This intensive (short duration) rotational management (Provenza *et al.*, 2006) could be realized through the use of electric fences or close shepherding control. The bottom-line of this chapter is that offering complementary forages as conterminal monocultures or grazing circuits have proven more beneficial for the nutrition of lactating sheep than intimate mixtures of the same species. Research on more complex grazing circuits for dairy sheep is urgently needed. Furthermore research is required to automate flock shepherding. 'Remote shepherding' has been suggested by the use of remote-controlled gates (Champion *et al.*, 2005), but a more intriguing and ambitious scientific target is the decoding of sheep vocalisation in order to re-play the 'key-bees' needed to lead flocks from the milk-shed along the grazing circuit and back. A first step in that direction has been the advancement of the acoustic monitoring of feeding behaviour (Ungar and Rutter, 2006).

SUPPLEMENTATION OF GRAZING SHEEP – Supplementation is another key facet of grazing management of dairy sheep since, in Mediterranean regions, concentrates represent a high proportion of energy intake in grazing dairy ewes. The main question is: how much is concentrate supplementation beneficial and efficient for grazing sheep nutrition and performance? Pooling the results of different experiments on dairy sheep, we found that the milk response by concentrate supplementation, although evident, is usually less than expected (Figure 3). If we focus on the fiber vs. starch 'classical' comparison, there seems to be scope to move towards more fibrous concentrates. This is probably due to the substitution effect (Figure 4) as well as, some possible impairment of rumen function, at least at high supplementation levels. This is in line with what observed by Cannas *et al.* (2002) on the positive role of digestible fibre in diets offered *ad libitum* to stall-fed mid and late lactating dairy sheep. The use of high levels of starch supplement in grazing sheep is also risky in spring (mid-lactation) since grass can be still low in dietary NDF while WSC can be as high as 10-20% DM. The provision of a small amount of hay (say 300 g DM per ewe), even when pasture is available, is considered a way to let animal meet their fibre requirements and to prevent sub-acidosis in starchy concentrate supplemented sheep. As to the effect of the concentrate on the grazing system as a whole, the herbage-saving effect of concentrate supplementation is a mechanism of interest for farmers who like to keep considerably high stocking densities during winter (early lactation phase) when herbage allowance is usually insufficient as shown by Ligios *et al.* (2002). Furthermore concentrates in general and cereal-based ones in particular, are candidate to curb the release of N in the excreta as shown by Giovanetti et al. (2007) in lactating sheep fed pelleted diets ad libitum. However data by Decandia *et al.* (2007a), based on the same concentrates as above but offered as supplements (600 g/d) to grazing sheep did not confirm such results. Another possible way to improve the efficiency of N utilisation is the addition of tannin (e.g. chestnut tannins) to the concentrate. Results on this subject are still scanty for grazing sheep and no conclusion can be drawn upon them (see Mueller-Harvey, 2006).

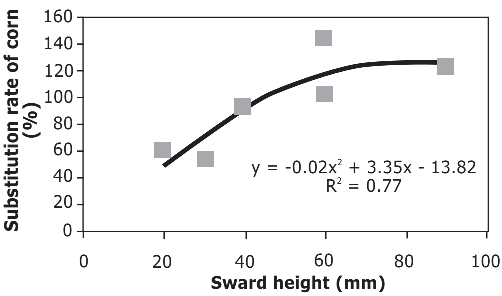
Figure 3. Milk response to concentrate by dairy ewes grazing or fed fresh forages, supplemented with fibrous (NDF 28-52 %, NFC 24-48 %) or starchy (NDF 21-22 %, NFC 48-60 %) concentrates at different levels. D'Urso et al., 1993; Avondo et al., 1995; Molle et al., 1997; Marques and Belo, 2001; Addis et al., 2005; Cabiddu et al., 2006b; Decandia et al., 2007a. Means and SEM.



MONITORING NUTRITIONAL UNBALANCE IN GRAZING ANIMALS – To effectively manage the complexity of the dairy sheep grazing systems in the light of new scientific achievements, decision support tools are required. Indeed, although a well based mechanistic feeding system focussed on dairy sheep has been recently released (Cannas *et al.*, 2004) its ability to predict intake and performance of grazing sheep has to be improved. Novel empirical prediction systems of small ruminant intakes based on regression analysis represent an important step forward in this direction (Avondo *et al.*, 2002, for sheep; Decandia *et al.*, 2005, for goats) but their practical application is risky outside the specific genetic (animal and forage) and environmental conditions wherein they were built. Mechanistic prediction systems of grazing sheep intake such as that by Baumont *et al.* (2004) are promising for a more significant and long-lasting scientific advancement but, in order to become practical for dairy sheep in Mediterranean environment, they need to integrate appropriate 'key' relationships, which are currently lacking.

Therefore whichever the estimate source, the assessment of grazing sheep nutrition balance has still to be tuned on the basis of indicators focussed either on the pasture (sward height, herbage mass, herbage allowance) or the animal (milk urea, body condition score, faecal score and obviously milk yield). On this subject, it is noteworthy that milk urea has confirmed under grazing regimen to be an effective gauge of protein nutrition as previously found by Cannas *et al.*

Figure 4. Substitution rate of corn (%) in dairy ewes continuously stocked on Italian ryegrass pastures at different sward heights (Molle et al., 1997).



1998, under controlled feeding regimen. In a three-year study, lactating sheep grazed three binary mixtures consisting of the same grass, namely annual ryegrass, and either burr medic, subclover (*Trifolium subterraneum)* or sulla. Pooling data (N=72) of the average group dietary CP percentage and plotting them against the average MUC a linear relationship was found which explained 0.55 of total variation (Molle *et al.,* 2007). According to this equation, for CP dietary levels ranging between 15 and 20% DM, MUC span from 32 to 43 mg/100 ml. A more fundamental research has shown that MUC relationship with CP is modulated by the dietary energy level in a way that the ratio between CP and NEL is the best single predictor of MUC after meta-analysis of the available literature on stall fed sheep (Giovanetti, 2007). A side-achievement of this study has been the finding that MUC is well related with N excretion as urine and N utilisation efficiency. Validating this relationship in grazing sheep will make MUC an outstanding variable for monitoring, beside nutrition, the environmental impact of dairy sheep industry. While the above results are promising, more relevant promises have been recently sourced from the implementation of NIRS faecal spectra for assessing the dietary composition and -currently with less accuracy- intake of browsing goats and sheep (Landau *et al.*, 2006) and stall fed sheep (Decandia *et al.* 2007b). This method is non invasive, environmental friendly and provides in short term accurate information as long as its calibration is well-based. Widening NIRS spectra database and standardising NIRS equipment at regional and wider scale is a sensible target if grazing livestock management has to make a quicker move from 'art' to 'technology'.

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